The packaging operation

The packaging operation comprises all the activities which are involved in combining a product with its packaging on what is known as the packaging line.

The packaging line is set up in order to meet the speed and overall quantities of the product to be packed and may range from manual operation up to high speed fully automatic operation.

The packaging operation also includes the storage and handling of the packaging prior to its use on the packaging line and in the assembly of transit packages for storage and distribution.

The packaging line efficiency is dependent on the machine, or method in the case of a manually operated line, the product, the operators, and the quality of the packaging material. The two most important tasks to fulfil on the packaging line are to minimise the number of damaged packages and to maximise the output.

Packaging based on primary fibre paperboard gives the best performance, uniformity and consistency. The packaging producer should be aware of the cost implications of packaging efficiency as it can have an important influence on the overall packaging cost.

Description of the packaging line
On the packaging line the sequence of operations is:
• Feeding from a box or magazine.
• Forming or erecting flat blanks or side-seam glued blanks depending on the structural design – forming may involve gluing, heat sealing or locking.
• Filling, i.e. inserting the product.
• Closing the carton by gluing, heat sealing or tucking of flaps depending on the structural design.

Cartons are supplied to the packaging line as flat blanks or folded side-seam glued cartons with open ends. The feeding of the blanks depends on the design of the packaging line.

The flat blanks are erected either by a special tool with a block-like shape, which presses down on the blank to form the base and sides of the carton, or by folding around a mandrel, i.e. a former. If the blanks are side-seam glued cartons, then either the opposite folded creases are squeezed and vacuumised suction devises are applied to adjacent panels as the blank is moved from magazine to conveyer, or a tool is inserted flat and turned through 90° to open the carton.

The filling operation can be carried out on the horizontal plane or on the vertical plane. The nature of the product determines the filling method. The carton may be closed at one end prior to product loading, as is the case with vertical product loading. The closing operation might be by tuck-in flaps, gluing the flaps or heat sealing, or tab insertion and locking. For extra protection, the package might be overwrapped with a plastic film.

The unit packages are check weighed to ensure product accuracy. If the product is a foodstuff a metal detection procedure is common. The unit packages are then loaded into a transit package and the packaging operation is usually completed by palletisation.
A cigarette packaging machine typically runs at speeds of 350 to 1000 packs per minute, requiring a paperboard with perfect performance in flatness, gluing properties and friction. Illustration background courtesy of Focke & Co. (GmbH & Co. KG) Verpackungsmaschinen.
Folding

The folding operation is dependent on the creases. For rectangular shaped cartons, the curvature of the panels and flaps should be minimised. This is achieved by maximum creasing to minimise the residual bending resistance combined with adequate paperboard stiffness. Curved panels affect the dimensions and shapes and can cause packaging machine disturbances by exceeding geometrical tolerances. Curved panels will have a significantly increased bending resistance due to their shape. Curved panels usually have a negative impact on the final appearance of the carton.

The folding resistance of a curved panel increases dramatically with curvature. Calculations on curved panels give results as shown below. It can be seen that even limited curvature induces increased resistance to bending and will risk failure in the packaging machine due to bending beside the crease.

A study performed by Packforsk (now Innventia), has shown that problems caused by curvature depend on the conditions in the packaging machine. Heavy, rigid and supporting products combined with fixed (well-clamped) panels are more critical to curvature. A looser clamping or lighter, more fluid product is less critical since the box is allowed to self-compensate for some of the problems caused by curvature.

The moment of inertia is proportional to stiffness.

One example of folding and erecting
The conclusions of the study were that packaging machine settings are vital. For example, the degree of clamping is one of the most important factors. The clamping can be firm, which means that the free length of the clamped panels, L, is short. The folding result with firm clamping depends on the curvature of the flap \(1/r\) and the width of the flap.

Looser clamping is less critical and gives better folding results. The properties of the paperboard and the quality of the creases have a major influence on the result. In practice the clamping is usually neither firm nor loose. When folding after filling the carton, the presence of the product can improve the folding operation.
The most common problem results when the folding does not occur along the pre-marked crease.

In graphical applications the finishing operation includes the folding operation. Graphical products are mostly book covers, catalogues, etc., so the folding angle is often 180°.

Packaging line efficiency
Packaging line efficiency is expressed by the actual output compared with the expected output.

In determining the expected output in a given time it is important to establish a rate of packaging based on the real time available for packaging. This means that set up times, routine maintenance time etc. are eliminated from the overall production time used in the calculation.

During the time available for packaging it is important to record the reasons for stoppages and periods of slower production speed. It is then possible over a period of time to identify problems which need attention, particularly problems that may be packaging material related. Such studies frequently reveal problems associated with machine settings and in the handling and storage of packaging materials prior to use.

A material audit is a useful additional routine method of checking. In this procedure the quantity of packaging material issued to the machine is compared with the number of saleable packages delivered from the machine over a given period.

High efficiency in the packaging operation reduces overall packaging costs. It should be remembered that low efficiency not only means wasted cartons, often of much greater cost significance is wasted product, wasted machine time, and losses in market share due to late and short deliveries. All these factors should be taken into account.

Key paperboard characteristics
The key paperboard characteristics required for packaging line efficiency are mainly related to strength, creasability, foldability, glueability, sealability, flatness, and dimensional stability. Variability in these properties and in the relevant structural design features of cartons and other forms of packaging based on paperboard can cause disturbances in the optimum settings necessary to achieve efficient performance in the packaging operation.

Uniformity of all relevant properties within an order and consistency in these properties from order to order is very important for good efficiency (which is also referred to as good runnability).

Uniformity in these properties is a feature of multi-ply paperboard such as Solid Bleached Board and Folding Box Board. This is because these types of paperboard are based on primary fibre of known composition and treatment, processed on fully automated paperboard machines.

Key properties
Key features for performing the packaging operation:
- grammage
- thickness
- flatness and dimensional stability
- moisture content
- stiffness and stiffness ratio
- plybond
- creasing and folding efficiency
- glueability or heat sealability for plastic-coated paperboard
- water absorption
- tensile strength
- tear strength
- delamination strength
- clean edges and surfaces
- freedom from hazardous contamination.

Packaging in practice
Adequate packaging and protection of cartons prior to use on the packaging line is necessary to avoid physical shape distortion. This protection is essential for efficient feeding, erection and carton presentation. Moisture-proof wrapping should be used by the cartonmaker when flatness, shape, and dimensional stability are critical. Extremes of temperature and humidity should be avoided.

It is very important to allow cartons to achieve temperature equilibrium with the environment of the packaging room before the cartons are unwrapped. The time required to achieve this depends on the type of packaging used to supply the cartons, or carton blanks, and the difference in temperature between the store and the packaging room. If the cartons are colder than the packaging room when they are unwrapped, moisture may condense on the cartons causing shape distortion and loss of stiffness. See the chapter General technical information in the Product Catalogue for information about warm-up times.

When cartons remain unused at the end of an order or day’s work, it is important to re-wrap them with moisture-resistant material. The paperboard is manufactured to a set moisture content to match the expected relative humidity (45–60% RH, at 20-22 °C). Any significant difference between the packaging room climate and the cartons will affect the moisture content upwards or downwards causing changes in dimension and shape.

The following factors are essential for good packaging:
- The packaging line must have design features which make it suitable for handling the design and size of the cartons involved.
- Adjustment of the variable settings is particularly relevant on machines which undergo regular carton size changes. Visual guides and accurate pre-setting techniques are now available.
- Regular attention must be paid to the mechanical maintenance and cleanliness of the packaging line.
- The training, skill and motivation of the operating and engineering staff are critically important to good efficiency.
## Packaging features

<table>
<thead>
<tr>
<th>Packaging features</th>
<th>Description</th>
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<tbody>
<tr>
<td>Dimensional accuracy</td>
<td>It is important that every carton blank used on the packaging line accurately conforms to the specification drawing and has an identical profile. This is best achieved by laser cutting of dies (forms) and routing of counter dies (make-readies).</td>
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<tr>
<td>Creasing</td>
<td>It is important to use optimum creasing conditions (rule thickness, width and depth of groove) to ensure consistent folding in packaging. If the folding resistance is too high in relation to the paperboard stiffness it can result in panel bowing and poor runnability. Each paperboard type requires its own specific tool settings to give the best result.</td>
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<td>Frictional properties</td>
<td>Ink and varnish specifications significantly influence print rub and surface slip.</td>
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<td>Cutting</td>
<td>Sharp clean cutting with the absence of swarf and shattering on the backs of the paperboard.</td>
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<td>Flatness</td>
<td>This feature is particularly relevant to cartons which are supplied flat to the packaging line. This feature can be influenced by printing (print-induced curl).</td>
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<tr>
<td>Correct alignment of glued side seam</td>
<td>Relevant to cartons which are side seamed by the cartonmaker. The glue flap must not be tapered or skewed as this will distort the carton.</td>
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<tr>
<td>Correct application of glue on side-seam glued cartons</td>
<td>The right amount of glue must be correctly positioned. Otherwise glue may squeeze out either on the inside of the carton preventing opening, or on the outside causing adjacent cartons to stick together.</td>
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<tr>
<td>Strength of perforations</td>
<td>Perforations must be neither too heavy so that they open during packaging, transit and merchandising, nor be so light that the customer cannot open the package.</td>
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<tr>
<td>Carton opening force</td>
<td>This is relevant in cartons side seamed by the cartonmaker and refers to the ease of opening the carton on the packaging line. It is controlled by the creasing, by pre-folding of the unfolded creases and by the pressure applied to the folded creases by the draw rolls on the gluing machine. The opening force measured directly at the gluer is critical, because subsequent tightness of packaging and storage conditions will cause this force to increase with time. It can be checked by measuring the height of a fixed number of cartons (the “bounce” feature). It is recommended that the storage of side-seamed cartons should not exceed three months for optimum packaging line efficiency.</td>
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<tr>
<td>Overwrapping</td>
<td>Where cartons are overwrapped with clear or printed film, the film must not stick to the printed or varnished surface under the heat-sealed areas.</td>
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<tr>
<td>Special requirements</td>
<td>In addition to the properties of paperboard and features of paperboard packaging already discussed, there are additional requirements. These can be due to either the nature of the product being packed, the packaging environment, or some aspect of distribution and use which require additional extrusions, laminations or other functional coatings in combination with the paperboard, e.g. for frozen foods and ovenable applications. These additional treatments have implications for the packaging operation in terms of erection, forming, or sealing.</td>
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